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Hamburg University of Applied Sciences

-Bachelor thesis-

To obtain the academic degree Bachelor of Science (B.Sc.)

In the Media Technology study program

Measurement-based investigation of the reaction from level meters to signals un- different dynamics

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Summary

This bachelor's thesis deals with the measurement of the response of output measurement devices.
They detect signals of varying dynamics. For this purpose, a measuring device developed by Victor Acuña is used.
A method is used that aims to enable such an evaluation using pulsed sine signals. The change in signal dynamics is measured via the crest factor and thus via
The duty cycle is controlled. The measurement results allow for an evaluation of the dynamic behavior of the control meters as well as the measurement method itself.

Abstract

This Bachelor Thesis is about the measurement of the reaction of audio meters at signals of different dynamics. For this purpose, a method developed by Victor Acuña is used, which, under the use of pulsed sine waves, shall enable an evaluation in this regard. The alteration of the signal dynamic is controlled by the Crest-Factor and therefore by the Dury Cycle. Through the results of the measurement, an evaluation of the dynamic response of the audio meters and the method of measurement itself can be done.

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1. Introduction

The concept of dynamics has become particularly relevant with the advent of digital audio processing.
Material has gained considerable importance. This is due to the increasing use of effects such as multi-
Band compressors during mastering are particularly noticeable in popular music productions.
It often has a significantly lower dynamic range than, for example, a recording of classical music.
These differences not only affect the aesthetic sensibilities of the listener, but also create-
if the need arises to consider the significance of large dynamic differences in the data to be processed
To become aware of signals for audio production.

The work documented below aims to clarify this meaning in relation to output meters.
investigate.

In professional production environments, level meters are indispensable. From the
A large part of the quality of the pro- depends on the correct interpretation of the values they display.
produced sound material. By using different measurement methods, the displayed-
However, level changes with altered dynamics can vary considerably depending on the device type.
The relevant properties and exact calculation or measurement methods of the devices are often
not known, or the information to be provided about the dynamic behavior is not suitable for
All device types are uniformly defined. For this reason, insights into their specific behavior when the
signal dynamics change can be quite relevant for the practice of sound production.
vant sein.

To investigate these effects of signals with different dynamics on such devices,
As part of this bachelor's thesis, a series of measurements was conducted to record the response of
different measuring instruments to changes in signal dynamics. This served as a model for...
This measurement was a method developed by Victor Acuña (see Acuña 2015: 584 f.), with wel-
This will allow for an investigation into said effects, especially in relation to VU meters.
should.

The following report documents this series of measurements and places the results in the context of
The previously explained problem was evaluated, and the measurement method used, as well as the
resulting insights, were assessed.

Chapter 2 begins by explaining the conceptual approach and theoretical foundations regarding signal
dynamics and modulation measurement. As an example of how to build a VU meter, a brief explanation
of the operating principle of a device suitable for the measurement experiment is also provided.
self-assembled device. Chapter 3 will then describe in more detail the measurement method used and

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The execution of the measurement is discussed. Finally, in Chapter 4, the presentation of the results is given.

Results and their evaluation take place. Finally, in Chapter 5, the findings from the

The previous evaluation was summarized again and the applied measurement method was assessed.

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2. Theoretical foundations

2.1 Approach

To investigate the effect of different signal dynamics on level meters, it is useful to first create an overview of common device types. The functional-
The method and construction of a VU meter are explained using a self-assembled device as an example.
tert. By understanding the different measurement methods, the results of the investigation can be interpreted.
chung can be interpreted better. Furthermore, it should be determined which parameters the
The signal dynamics should be varied during the measurement experiment.

2.2 Control measuring devices

In order to make the best possible use of available system dynamics and to prevent overloads,
Signal level meters are used for visual monitoring of the signal level. Furthermore,
They offer a way to better match the audio material to the levels of other recordings, or other sources.
To adapt program content (cf. Weinzierl 2008: 552).

There are two basic types of devices for monitoring the current level: the VU meter.
and the peak program level meter (PPM) or peak voltage level meter.

The specified properties and construction of the VU meter can be found in DIN IEC 268-17.
(German Institute for Standardization e.V. 1992). The VU meter is an electromechanical-
sches measuring instrument, which mainly consists of a measuring mechanism with a front-mounted full-wave oscillator
It consists of a rectifier and an attenuator with adjustable damping. The display is linear, while the scale is
logarithmic (see Figure 2.1).

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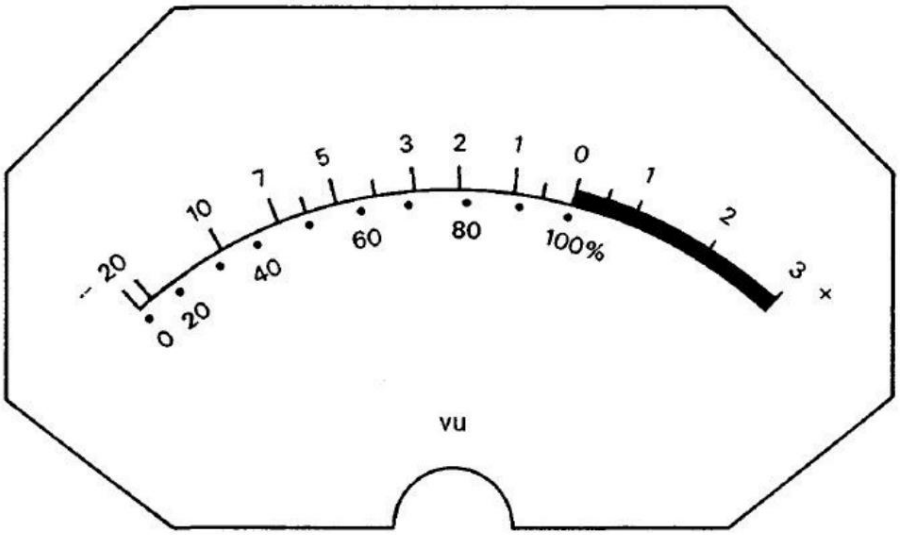

Figure 2.1: Sample of the commonly used scale type for VU meters from (German Institute for standardization eV 1992: 5)

The properties and different designs of peak voltage
Level measuring devices are defined in DIN IEC 60268-10 (German Institute for Standardization eV 1994) described. In addition to a rectifier and an integration circuit, the setup often contains Elemente, which show an approximately logarithmic relationship between the measured peak voltage value and the device's display. The display is stepped on most devices (see illustration-
(see section 2.2). Due to differing traditions and standards, several different [methods] are found.
Display types and their uses. A detailed explanation of the different displays is provided, for example, by winezierl (cf. Weinzierl 2008: 556 f.). However, the devices described in DIN IEC 60268-10 only serve this purpose. to represent the so-called "quasi-peak level". Particularly short voltage peaks, which
Information that is not perceptible to the listener and therefore not relevant is ignored (Ballou 2015:
110). However, specifically for the requirements of a digital recording environment, where even short overloads lead to clearly audible distortions, ITU-R BS.1770-4 (International Telecommunication Union 2015: 16 f.) presents an algorithm for calculating the “true peak” value. This is primarily based on oversampling the signal to be measured, so that even the shortest amplitudes can be captured.

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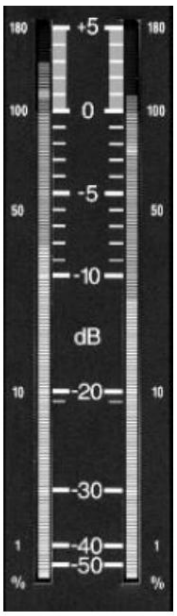

Figure 2.2: Display of a peak voltage level meter with DIN scale according to DIN IEC 60268-10 from (Weinzierl 2008: 557)

While peak voltage level meters determine the peak value through short averaging periods (Sample accuracy down to 10ms) should be displayed as precisely as possible (cf. German Institute for Standardization eV 1994: 6), the VU meter measures due to the comparatively long settling time (300ms ± 10% according to DIN IEC 60268-17) “[...] a value between the rectified average value and the RMS value” (Weinzierl 2008: 558). Thus, the display behavior of the VU meter, in contrast to Spit-Zenspannungs-Ausmessungszählern vor sich lieber zu Menschen Gehörspüren (cf. Shepherd 2008: 304). Even though VU meters are used less and less these days, a more precise measurement is worthwhile. Qualitative assessment of the devices is based, not least, on this characteristic. It is not exclusive- It is likely that this type of level meter will continue to exist as a cost-effective alternative for a longer period of time.

The most important characteristics of both device types, as defined in the relevant standards, are Weinzierl has summarized this clearly (see Table 2.1). The information refers to from DIN IEC 60268-17 on VU meters, those from DIN IEC 60268-10 on peak voltage meters Control measuring devices.

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Eigenschaft	Bedeutung / Messverfahren	Standard
Bezugsanzeige	Jedes Instrument hat einen Referenzpunkt auf seiner Anzeige. Dieser Referenzpunkt ist per se keinem bestimmten Signalpegel zugeordnet, soll jedoch so gewählt sein, dass er vom Programmpegel nur selten überschritten wird.	DIN IEC 60268-10 DIN IEC 60268-17 ITU-T J.27
Bezugs-Eingangsspannung (Bezugspegel)	Effektivwert eines stationären Sinussignals von 1000 Hz, der die Bezugsanzeige ergibt.	DIN IEC 60268-10 DIN IEC 60268-17
Integrationszeit	Dauer eines Tonimpulses eines 5 kHz-Sinussignals bei Bezugspegel, die eine Anzeige 2 dB unter Bezugsanzeige ergibt.	DIN IEC 60268-10
Einschwingzeit	Zeit, in der der Zeiger bei Anlegen des Bezugspegels 99 % der Bezugsanzeige erreicht.	DIN IEC 60268-17
Rücklaufzeit	Zeit, in der die Anzeige nach dem Abschalten eines stationären Eingangssignals von der Bezugsanzeige auf einen definierten Punkt der Skala abfällt.	DIN IEC 60268-10 DIN IEC 60268-17

Table 2.1: Specific properties of control measuring devices from (Weinzierl 2008: 555)

In addition, measuring devices are used to monitor the volume of audio material. Besides
Measures such as incorporating human hearing perception are the basis of the most common algorithms.
Algorithms for measuring loudness based on the recording of the RMS value (see International Tele-
communication Union 2015: 3, 8) about longer mediation times (cf. Weinzierl 2008: 555) and partial-
also about the complete program content (cf. European Broadcasting Union 2014: 5).

The dynamic behavior of the devices is characterized in the case of the VU meter by the specification of the settling time, decay time, and overshoot behavior. The peak voltage-
In this respect, level meters are distinguished by the specification of delay time (corresponding analogously to the settling time of a VU meter), integration time (see Table 2.1), over-
Oscillation behavior (corresponds analogously to the specification prescribed for VU meters) and return flow
time is characterized. Furthermore, the dynamic behavior of the latter is to be characterized by the results.
a measurement with sinusoidal voltage pulses of fixed frequency, in which the pulse duration is shortened and
The corresponding displayed levels are recorded and specified. Furthermore, there are also...
further measurements, in which pulse duration, amplitude or frequency are varied, were performed.
give. Apart from the fact that the aforementioned information only partially finds its way into the data sheets-

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talking devices find[1] could the description of the dynamic properties for the end-
Users should be able to formulate and present information in a more uniform way.

In summary, the following values can initially be considered crucial for measuring the control output:
Name the peak value, the average rectified value (ARV), and the effective value (RMS). Furthermore...
There appear to be guidelines for a uniform representation of the dynamic behavior of the devices, which are in
The scope and comprehensibility of the information in data sheets/operating instructions are appropriate,
to be missing.

2.3 Structure and Function of the Self-Assembled VU Meter

To improve the comparability of the qualities of the measured devices with regard to the results of the measurements-
The results and findings were developed in addition to those manufactured for professional use.
Measuring instruments also include a VU meter assembled from prefabricated elements.
the measurement was included.

As an example of the structure and function of VU meters, the following will be discussed:
The components of this self-assembled device will be examined in more detail.

The SEW ST-475 was used as the measuring instrument with a corresponding scale (see Figure 2.3).
This is a moving-coil measuring instrument with a core magnet (see Figure 2.4). Due to the in
A homogeneous magnetic field is generated inside a permanently mounted coil.
This is generated by applying a voltage to the moving coil and the resulting current flow.
In combination with the magnetic field, an electrical torque is created, which causes a deflection.
of the pointer (cf. Felderhoff: 87 f.).

[1] e.g. in the RTW 1206D (RTW 2004:2)
[2] For further information see (SEW oJ)

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Figure 2.3: SEW ST-475

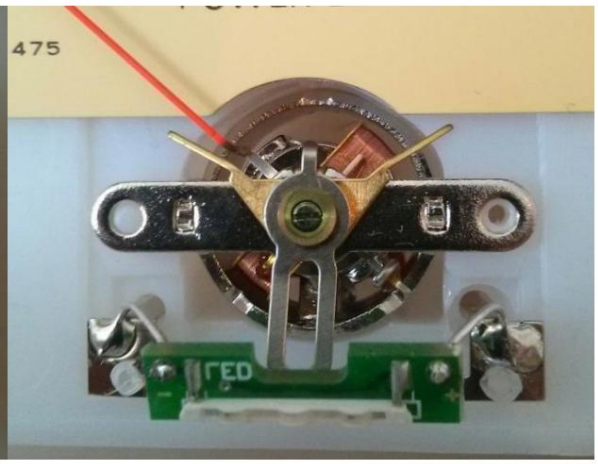

Figure 2.4: Moving-coil measuring instrument of the SEW ST-475

Using a pre-made circuit board (see JLM Audio oJ), a circuit was created whose design-
The construction can be seen in part in Figure 2.5. Other parts of the circuit diagram relate to the power supply and the control of an optional LED peak indicator.

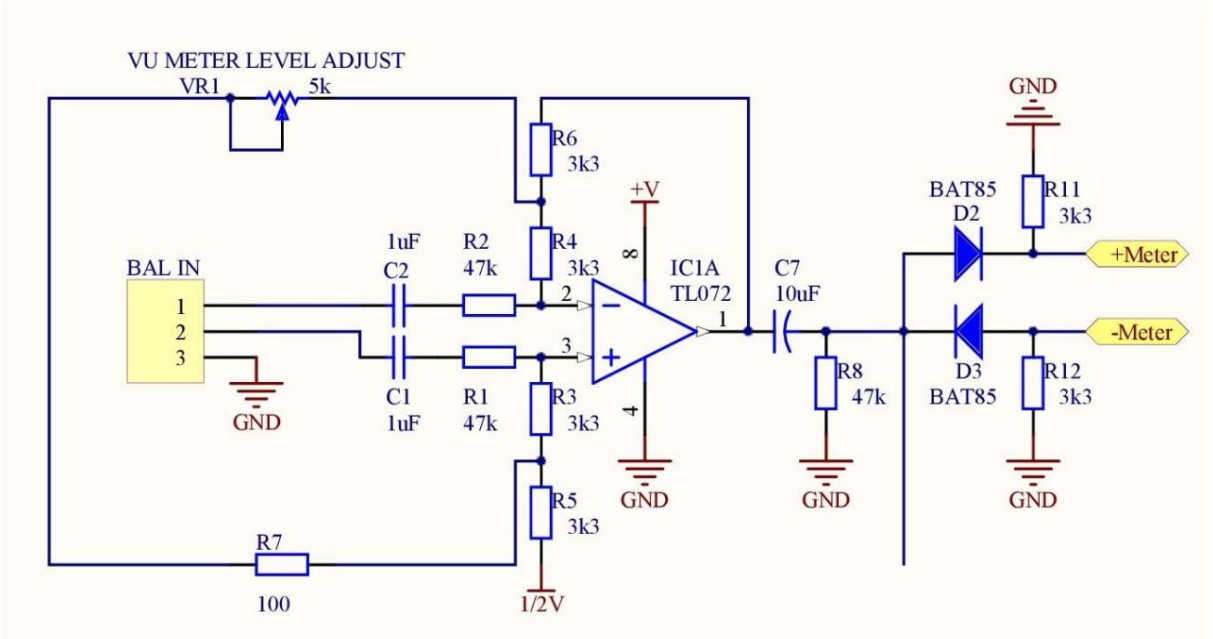

Figure 2.5: Excerpt of the circuit diagram of the JLM Audio VU meter buffer from (JLM Audio 2013)

The main task of the circuit is to process the incoming signal with as little distortion as possible using the TL072. and to amplify with low noise, whereby the level of the resulting voltage can be adjusted via the adjustable Resistor VR1 can be controlled. Diodes D2 and D3 then serve as rectifiers.

This is necessary because the deflection direction of the moving-coil measuring instrument depends on the polarity of the applied voltage depends on the direction of the current.

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The finished circuit can be seen in Figure 2.6.

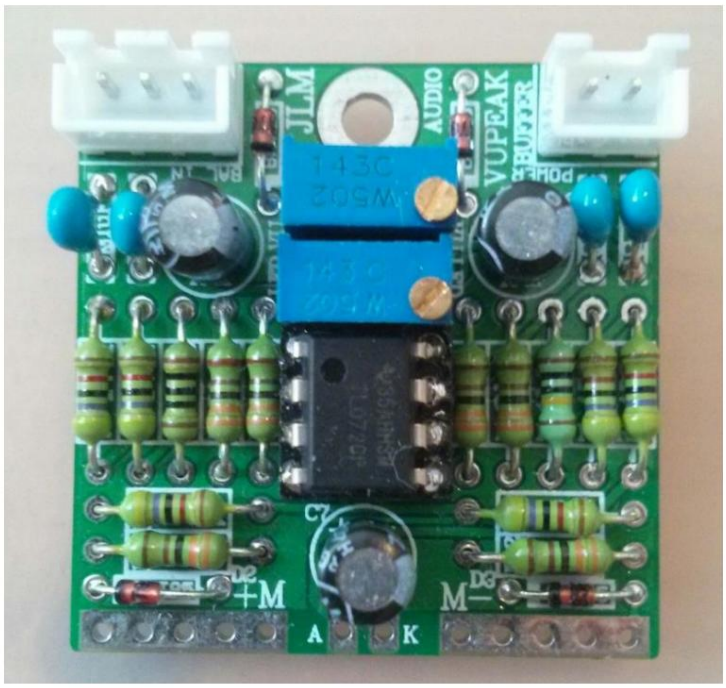

Figure 2.6: Completed JLM Audio VU meter buffer

2.4 Signal Dynamics

The crest factor is a suitable indicator for the dynamics of audio signals.3

This expresses the ratio of the peak value ′ to the effective value *U* of an alternating voltage

The formula for the RMS value of a periodically time-dependent voltage u is:

$$= \ddot{y}\,\ddot{y} \qquad (2.1)$$

(See Hagmann 2011: 207)

[3] The crest factor is used, for example, in the software "TT Dynamic Range Meter" to capture the dynamics of audio signals (see Pleasurize Music Foundation: 12).

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The crest factor is defined as:

$$= \frac{}{} \quad (2.2)$$

(See Hagmann 2011: 211)

Since the crest factor in music production can vary from over 10 dB to 20 dB, this would also apply the displayed values of a level meter, depending on whether the RMS value or the Amplitude is measured to differentiate by this factor (see Rane Corporation n.d.).

To change the dynamics, i.e. the crest factor, of a signal, it is advisable to use the RMS value. to influence the signal. This can be achieved when using a pulsed signal by sub- Different duty cycles are achieved. The duty cycle *g* describes the ratio of pulse duration to peri- trip duration T and is defined as:

$$= \frac{}{} \quad (2.3)$$

(See Freyer 2013: 23)

How exactly the duty cycle affects the RMS value of the signal and thus its crest factor- Its effect can be recognized by a rectangular pulse voltage, for whose RMS value depends on- The following applies to the degree of duty:

$$= \ddot{y}\,\ddot{y}\,\frac{}{}\,\frac{}{} \quad (2.4)$$

(See Bastian 2012: 131)

Assuming a sine wave signal, the aforementioned relationship for the effective value can be derived. Describe the value as follows:

$$= \frac{}{\ddot{y}}\,\frac{}{\ddot{y}\,\ddot{y}} \quad (2.5)$$

In summary, the dynamics of a pulsed sine signal can be described by the crest factor. express which, with constant amplitude, is achieved by changing the duty cycle, and thus the effective value can be influenced.

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Furthermore, the rectified average value and the amplitude of the sine signal can be calculated using the following formulas if the effective value is known. For the rectified average value | | applies:

| = (2.6)

(See Hagmann 2011: 205)

For the amplitude applies:

= ÿ ÿ (2.7)

(See Hagmann 2011: 208)

The described relationships between crest factor/duty cycle and the values measurable for a sine signal are presented below in tabular form (see Table 2.2) and graphically (see Figure 2.7).

Duty Cycle 1	Crest-Faktor in dB	Peak in dB	RMS in dB	ARV in dB
	3,0	0.0	-3,0	-3,9
1/2	6,0	0.0	-6,0	-9,9
1/3	7,8	0.0	-7,8	-13,5
1/4	9,0	0.0	-9,0	-16,0
1/5	10,0	0.0	-10,0	-17,9
1/6	10,8	0.0	-10,8	-19,5
1/7	11,5	0.0	-11,5	-20,8
1/8	12,0	0.0	-12,0	-22,0
1/9	12,6	0.0	-12,6	-23,0
1/10	13,0	0.0	-13,0	-23,9
1/11	13,4	0.0	-13,4	-24,7
1/12	13,8	0.0	-13,8	-25,5
1/13	14,1	0.0	-14,1	-26,2
1/14	14,5	0.0	-14,5	-26,8
1/15	14,8	0.0	-14,8	-27,4
1/16	15,1	0.0	-15,1	-28,0
1/17	15,3	0.0	-15,3	-28,5
1/18	15,6	0.0	-15,6	-29,0
1/19	15,8	0.0	-15,8	-29,5
1/20	16,0	0.0	-16,0	-29,9
1/30	17,8	0.0	-17,8	-33,5
1/50	20,0	0.0	-20,0	-37,9

0.0 *Table 2.2: Tabular overview of the relationship between duty cycle, crest factor,*

Peak, RMS und ARV

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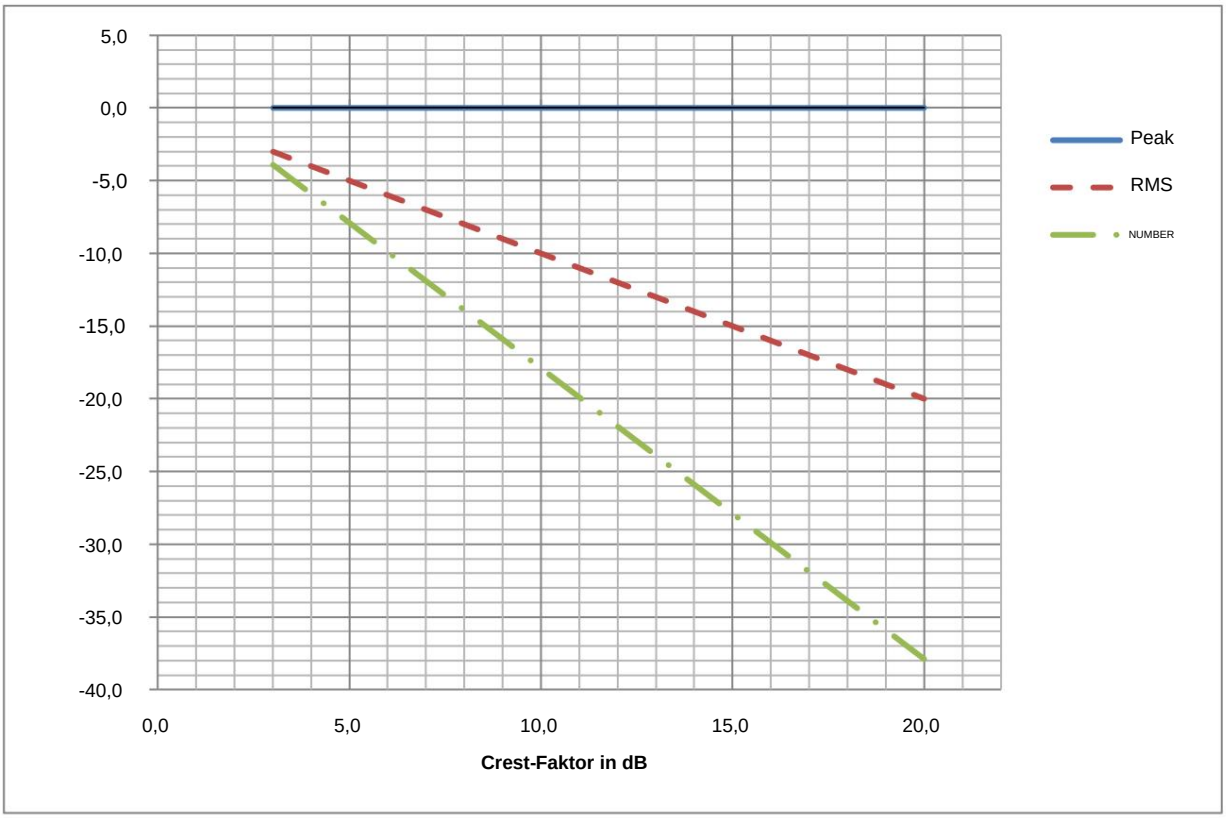

Figure 2.7: Plot of peak, RMS and ARV as a function of the crest factor

Ideal measuring devices would, depending on whether they are measuring the peak, RMS, or ARV value of a signal...

They should display exactly those levels from Table 2.2. The illustration in Figure 2.7 shows that...

It is easy to see how strongly the dynamics of the signal affect the respective displayed levels.

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3. Measurement setup and execution of the measurements

Taking into account the information and considerations presented in Chapter 2, the following applies:
the experimental setup based on the model of the measurement carried out by Acuña (see Acuña 2015) as
The following is done: Using a pulsed sine signal, the dynamic behavior of different control measuring devices
is investigated by changing the pulse duration.

3.1 Hardware and software used

The free audio editor software “Audacity” was used to generate the signal.[4] The playback-
The signal was drawn and edited for the measurements using the software “Studio One 3 Prime” from the
company “PreSonus”, which is a free trial version of the DAW software.[5] The
Playback took place via a balanced output of the USB interface “Saffire 6 USB” from the company “Focusrite”[6] .

To prevent distortion of the measured values, the linearity of the USB output was checked.
Interfaces were measured beforehand at approximately 90% of the maximum gain adjustable on the interface.
checked (see Table 3.1). Above 3 dBFS, the expected distortions begin, un-
Below this limit, the interface operates sufficiently linearly. Measurements were taken at a constant-
continuous sine wave signal with a frequency of 1000Hz.

The digital multimeter “Hyelec MS8233D” was used for AC voltage measurement[7] .

[4] For more information see (Audacity Development team oJ)
[5] For further information see (PreSonus 2015)
[6] For further information see (Focusrite n.d.)
[7] For further information see (Goods archive oJ)

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dBFS	Voltage at the output in Volt	Output voltage in dB
5	2,440	4,2
4	2,300	3,7
3	2,120	3,0
2	1,895	2,1
1	1,687	1,0
0	1,496	0,0
-1	1,341	-1,0
-2	1,195	-2,0
-3	1,064	-3,0
-4	0,948	-4,0
-5	0,844	-5,0
-6	0,752	-6,0
-7	0,670	-7,0
-8	0,597	-8,0
-9	0,531	-9,0
-10	0,473	-10,0
-15	0,264	-15,1
-20	0,147	-20,2
-25	0,082	-25,2
-30	0,047	-30,1
-50	0,004	-51,5

Table 3.1: Measured voltage at the output of the Saffire 6 USB interface

3.2 Control measuring devices used

The control measuring devices used for the measurement come from different operational backgrounds.

sufficient. For example, in addition to individual devices, measuring instruments were used which were also used in other audio engineering applications.

are installed in devices. This should verify whether the measurement method is uniform on

Level meters from different application areas and with different requirements-

applicable and delivers usable results. Unless otherwise specified, for

The name of the entire device is used below for the built-in measuring instruments.

Since the measurement method described by Acuña is primarily suitable for VU meters and for these

More precise information about the dynamic behavior is rarely provided, or it is difficult to determine.

Although they can be distinguished for technical reasons (cf. Acuña 2015: 584), mainly sol-

che devices were selected for measurement.

Since the measurement is primarily aimed at a more precise characterization of the devices with regard to measurement accuracy-

The question of whether it aims for ness and dynamic behavior and should be uniformly applicable will not be addressed here.

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The information provided for the devices in this regard was examined in more detail. The information from the

Measurement data should also be obtained without more detailed knowledge of the properties of the individual measurement devices.

The instruments must be evaluable.

The following devices were used for the measurements:

- RTW 1204A Peakmeter[8] operated with a 10 ms integration time (see Figure 3.2).
- The custom-built VU meter, the construction of which is described in more detail in Chapter 2.3.

  (see Figure 3.1).
- A DK Audio MSD100T[9] operated in VU mode (see Figure 3.3).

  This is a device with analog inputs and a digital display, which is available in different-

  can be operated in different modes.
- A VU meter built into the API 2500 Stereo Compressor[10] (see Figure 3.4).
- A VU meter built into the Solid State Logic C200 HD[11] mixing console (see Figure 3.5).

Figure 3.1: Display of the SEW ST-745 used in the self-assembled VU meter

[8] For further information see (RTW oJ)
[9] For further information see (DK-Audio oJ)
[10] For further information see (API oJ)
[11] For further information see (Solid State Logic 2011)

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Figure 3.2: RTW 1204A

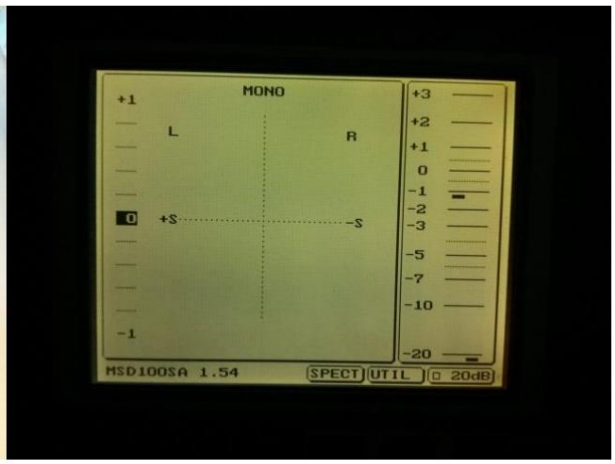

Figure 3.3: Display of the DK-Audio MSD100T in VU mode

Figure 3.4: Display of the VU meters of the API 2500 Stereo Compressor

Figure 3.5: Display of the VU meter of the Solid State Logic C200 HD

3.3 Measurement method

The following two measurements were performed for each level meter:

1. A measurement with a continuous sine wave signal, where the output voltage is at 0 dBFS
   by adjusting the output level of the USB interface to 0 dB (or 0
   The VU meter display is set. The corresponding RMS value
   The voltage is measured and recorded for a signal with a frequency of 1000 Hz. Then
   The level is changed in dBFS until the readable levels (depending on the device/scale) differ.
   (lich) are reached. The levels corresponding to the displayed levels are then recorded.
   Values in dBFS. These can be calculated using the RMS value at 0 dBFS.
   Determine the corresponding RMS, rectified mean, and peak values mathematically.

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2. Finally, to investigate the dynamic behavior of the control measuring devices,
the level of a continuous sine signal is set so that it provides the highest possible input-
The reading on the level meter indicates this. The pulse duration of the sine wave signal is then determined.
reduced until the levels visible on the level meter are reached. The applied-
The corresponding duty cycles shown are recorded. The period is
to choose such a way that the measuring device returns to its resting state between the pulses, i.e. the
The state without an applied signal has been reached again. This corresponds to the measurement specification.
of the dynamic behavior from DIN IEC 60268-10 (German Institute for Standardization eV
1994: 8). The measurement therefore begins with a period that is twice the return-
The runtime of the respective device corresponds to a duty cycle of 0.5. Here too,
Effective and rectified mean values were again determined mathematically, while the amplitude was not.
is changed.

Both measurement methods were, according to a recommendation put forward by Acuña to expand his
Following the measurement experiment (Acuña 2015: 589), using sine signals of different frequencies,
This leads to the selection of the frequencies used, namely 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz,
1000 Hz, 2000 Hz, 4000 Hz, 8000 Hz, 16000 Hz, is based on the standard derived from DIN EN ISO 266.
menen specification for standard frequencies and on the frequency range relevant for sound productions.

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4. Evaluation of the measurement results

When evaluating the measurement data, the differences between the results of the two in Ka- are particularly noteworthy.
Consider the measurements described in section 3.3. The dynamic behavior of the measured devices
This can be better assessed by comparing the display behavior when the supplied signal level changes with the
values displayed when the level changes via the crest factor.
The respective diagrams are labeled "Static" or "Dynamic". While in the
The first 0 dB on the display is equated with 0 dB RMS, and for comparison the graphs for RMS,
ARV and peak values are to be included in the plot; for the latter, it is advisable to include both the curve and the graph.
for the RMS and ARV values in the display at 0 dB level shown at 0 dB
To set the input level. This makes it easier to see the behavior of the level control.
The measuring device most closely follows the changing signal dynamics. The peak value remains unchanged.
This form of representation is also used by Acuña (Acuña 2015: 586 f.).

The levels supplied to the devices during the measurement of dynamic behavior can be determined by...
Calculate the known duty cycle/crest factor as described in Chapter 2.2.

Furthermore, it should be considered whether the reactions differ with a continuous or pulsed signal.
different frequencies.

Because, depending on the device and the frequency of the signal, the lowest values of the scale cannot be reached otherwise.
For the sake of completeness, the results for signals with a shorter duration were also included.
it is included as one period. This is especially noticeable with the peak meter and when using the
lower frequency signals are the case.

For the interpretation of the results, the different measurement methods must also be taken into account.
The periods used were due to the different response times. In the case of this measurement series, a response time
of approximately [value missing] was found for all VU meters, as well as for the DK-Audio MSD100T.
400 ms from the highest point of the scale. In contrast, for RTW 1204A it amounted to
these at 2.5 s.

The following section presents and evaluates the diagrams generated from the measurement data for all control
sensors used. Linear graphs indicate a visual...
The representation is omitted. Generally, the measurement results for measurements with a signature are presented.
The data is displayed at a frequency of 1000 Hz. Do the measurement results differ at other signal frequencies?
If the decrease is significant, it will be presented in an additional diagram.

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4.1 RTW 1204A

While with the RTW 1204A the displayed values remain constant across all frequencies with a continuous test signal
The measurements show that the levels correspond perfectly to the respective set levels.
The dynamic behavior exhibits some irregularities (see Figure 4.1). With a pulse duration
Below the set integration time of 10 ms, the displayed values decrease, as expected.
ten levels. However, for example, at a signal frequency of 1000 Hz, even displayed values below...
-3dB the pulse duration can be chosen to be shorter than that of a period.

Therefore, the actual dynamic behavior can only be deduced from the results to a limited extent, since
It is impossible to distinguish what is due to the influence of the possibly interrupted periods and what is due to the actual-
This behavior is attributable to changing signal dynamics.

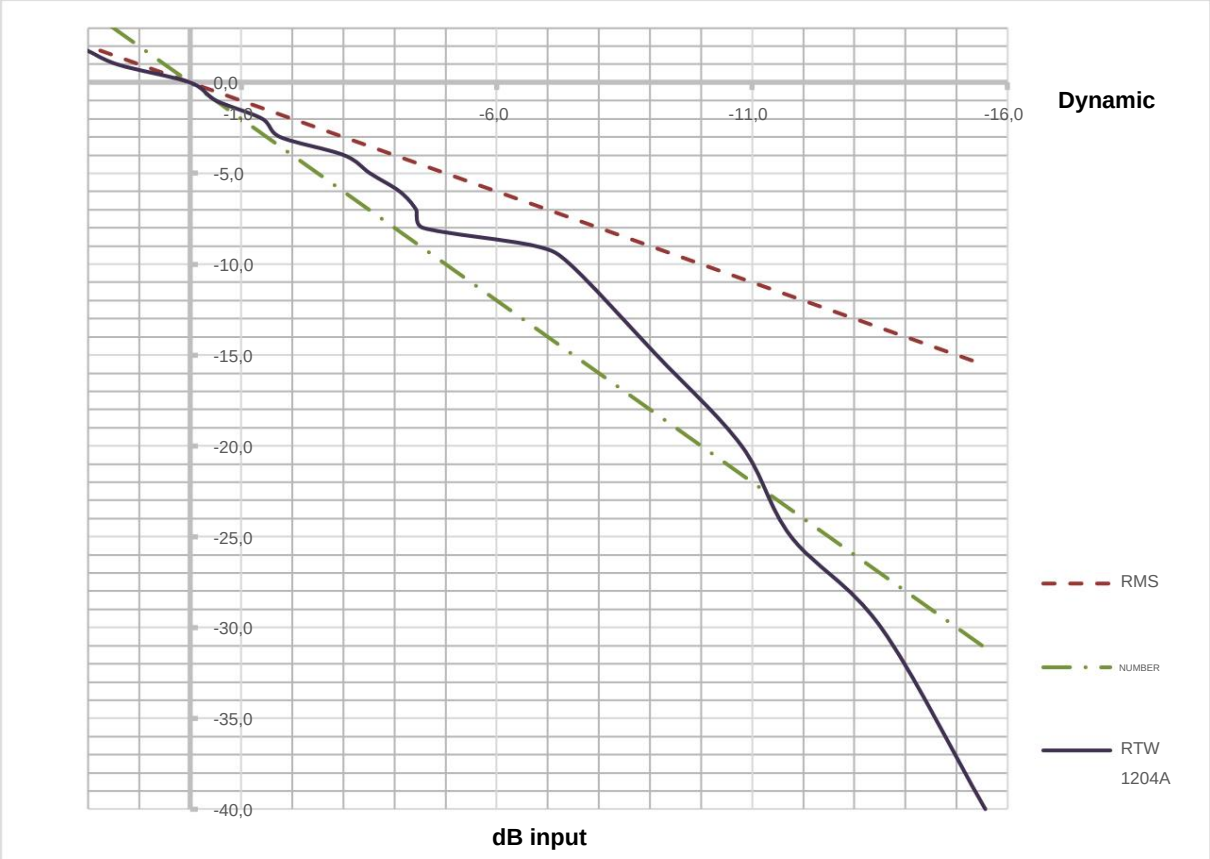

Figure 4.1: Representation of the results of the measurement of the dynamic behavior of the RTW 1024A with a signal at a frequency of 1000 Hz

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The previously described problem of excessively short impulses likely also explains the different-
The results are similar at other frequencies (see Figure 4.2).

At higher frequencies, however, a dynamic behavior of the RTW1204A can be observed, which lies between that of an ideal RMS/ and that of an ideal ARV meter.

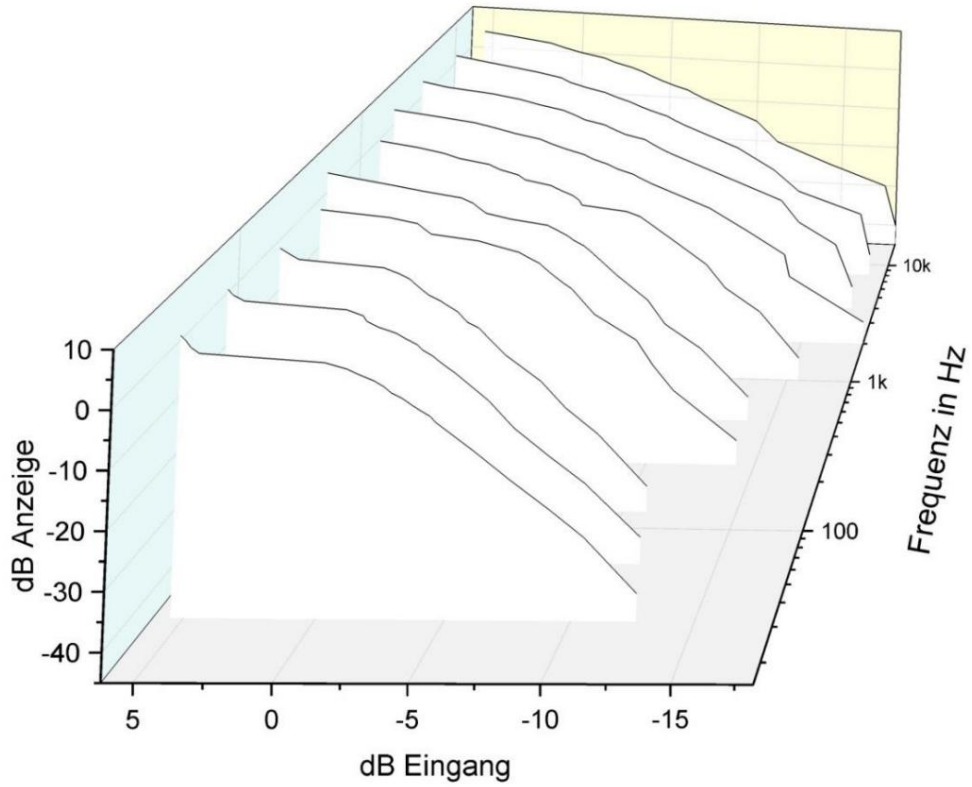

Figure 4.2: Representation of the results of the measurement of the dynamic behavior of the RTW 1204A with signals of different frequencies

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4.2 Self-assembled VU meter

When measured with a continuous signal, the VU meter shows a very inaccurate reading.
behavior (see Figure 4.3). If the device were calibrated to 0 VU at 0 dB, it would behave at low-
At higher input levels, the values displayed are far too high; from about -10dB, values even exceed the peak value.
Values. This can be observed across all tested signal frequencies.

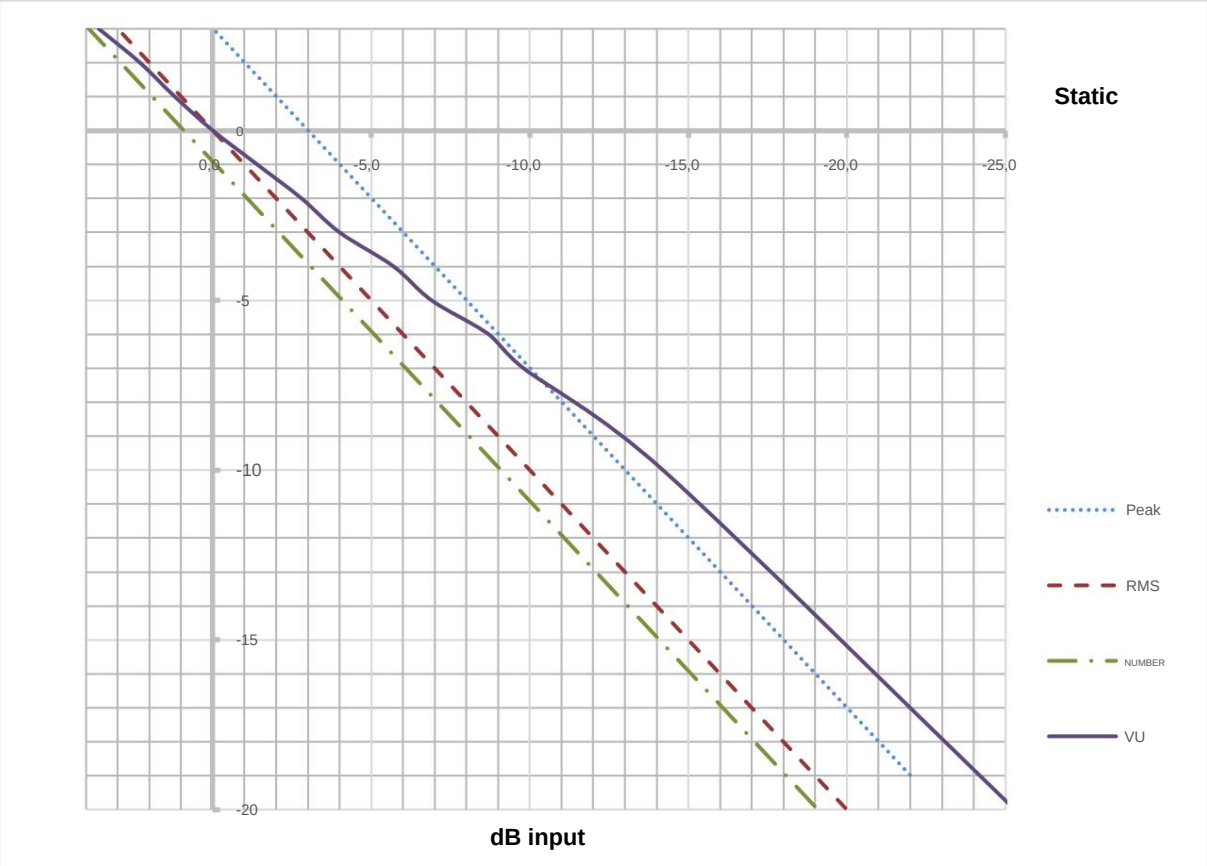

Figure 4.3: Representation of the results of the measurement of the self-assembled VU meter with a continuous signal with a frequency of 1000Hz

In contrast, the results of the measurement of dynamic behavior present themselves as follows:
remarkably close to the RMS values (see Figure 4.4). This difference could be explained by the fact that...
It may be that the measuring instrument operates linearly, but the circuitry upstream does not. With the same signal-
However, the measuring device would also approximate the RMS values with more dynamic signals.
reproduced correctly. At low frequencies, a different behavior is observed (see figure).
4.5), which can, however, be explained by the fact that pulse durations must be chosen for the lowest values of the scale that are shorter than the respective periods at these frequencies. Otherwise, the dynamic behavior across all measured frequencies is
similar.

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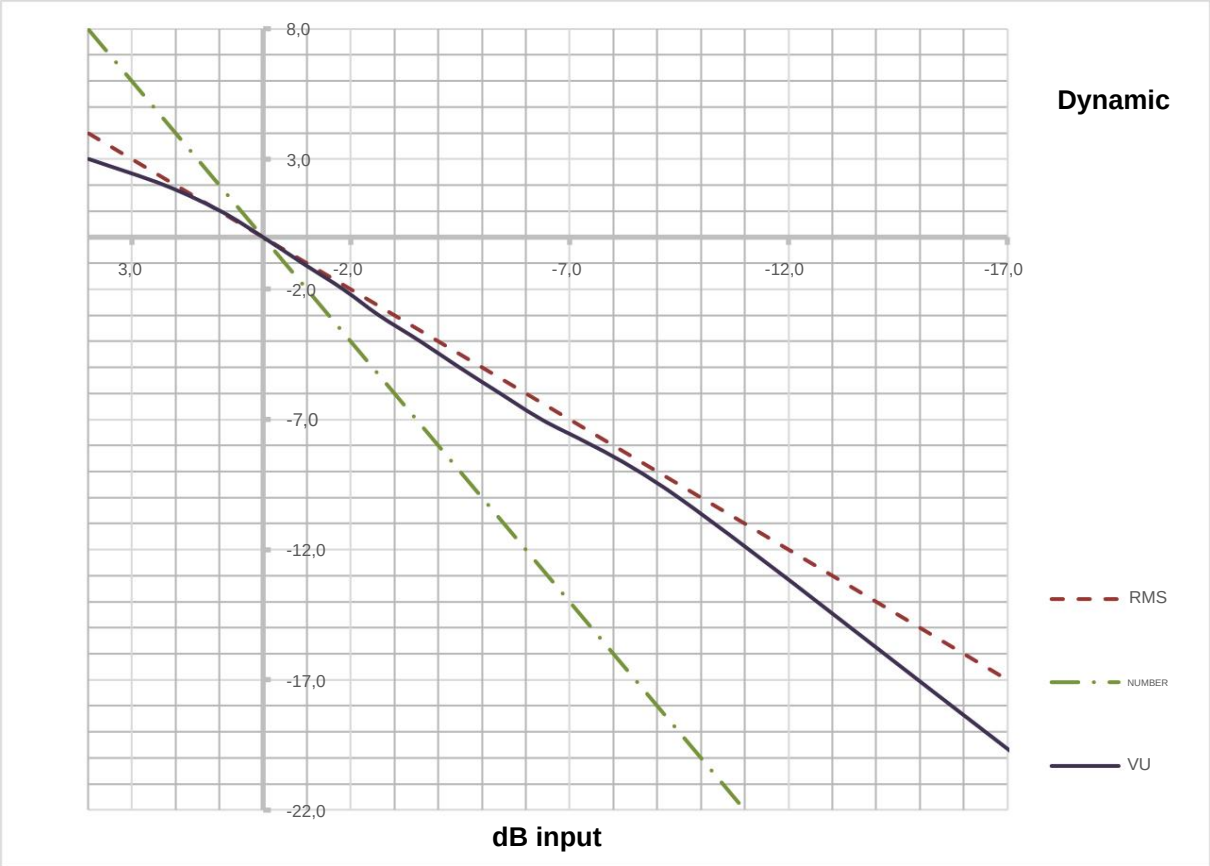

Figure 4.4: Representation of the results of the measurement of the dynamic behavior of the self-monitoring device.

VU meters with a signal at a frequency of 1000 Hz

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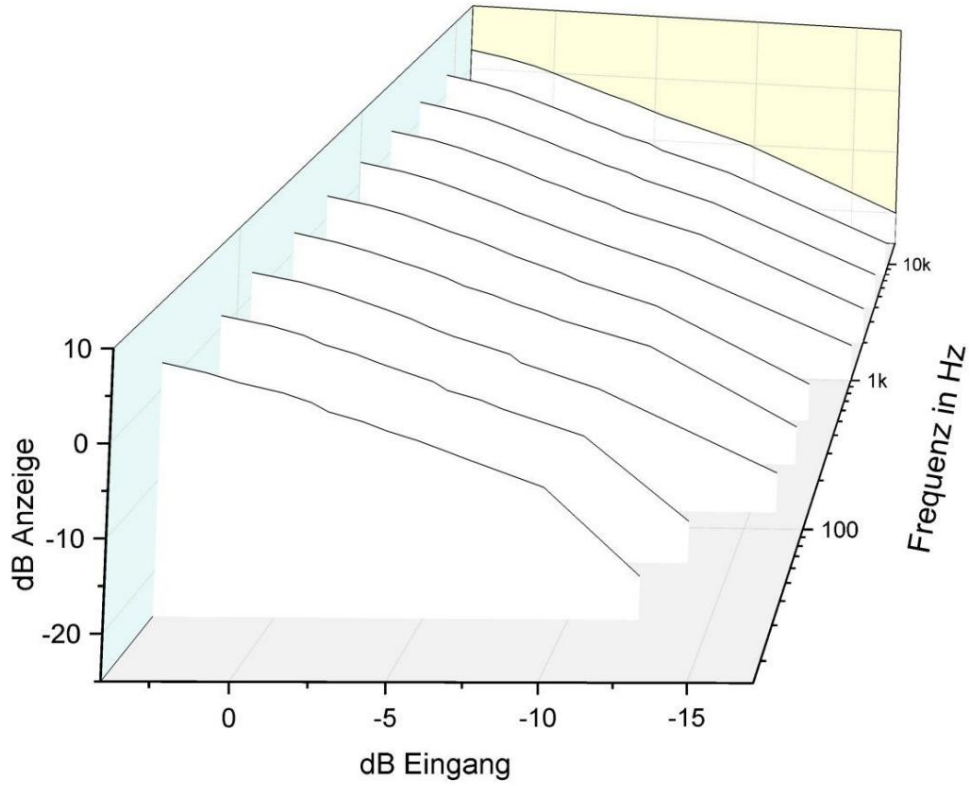

Figure 4.5: Representation of the results of the measurement of the self-assembled VU meter behavior of the RTW 1204A with signals of different frequencies

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4.3 DK-Audio MSD100T

This device also accurately displays the levels with a continuous signal. When measuring the dynamic range (dy-)
The namic behavior (see Figure 4.6) shows that the MSD100T is better suited for more dynamic signals.
Displays between the RMS and ARV values. At other signal frequencies, in-
Regularities can be identified (see Figure 4.7), which are also present at low frequencies.
This explains excessively short impulses. Other deviations could be due to the calculation/measurement methods.
This is due to the device's inherent limitations. Therefore, the characteristics of a VU meter are only partially replicated.
the.

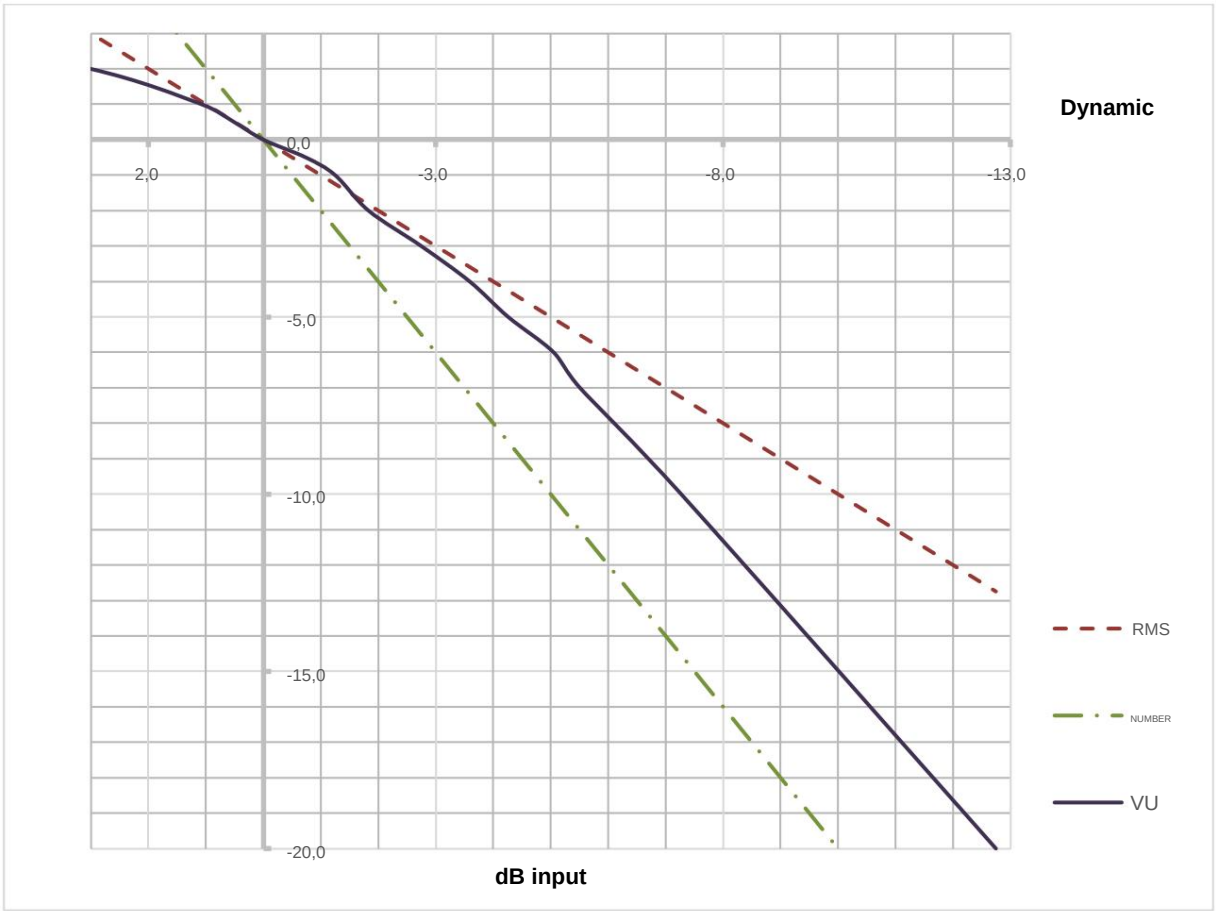

Figure 4.6: Representation of the results of the measurement of the dynamic behavior of the DK audio MSD100T with a signal at a frequency of 1000 Hz

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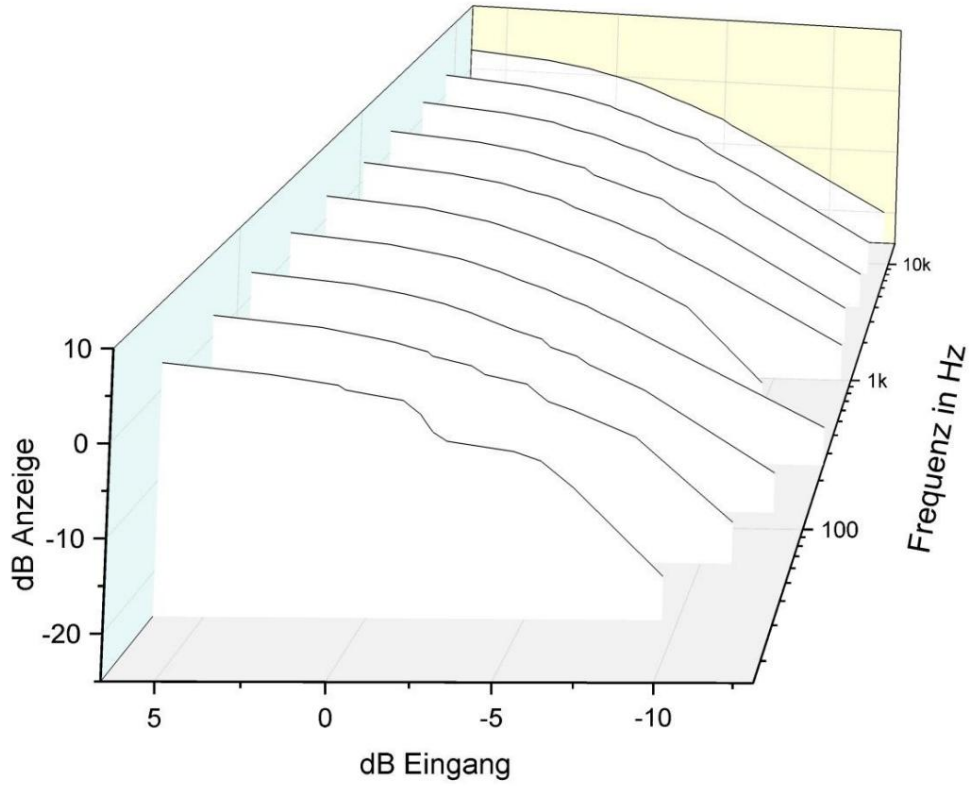

Figure 4.7: Representation of the results of the measurement of the dynamic behavior of the DK audio MSD100T with signals of different frequencies

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4.4 API 2500 Stereo Compressor

The values displayed by the API 2500 decrease when using the continuous measurement signal.
lower input levels are too high (see Figure 4.8). Calibration to 0 dB RMS would result in...
The lowest scale values show an approximate peak value. No change can be observed at different signal frequencies.

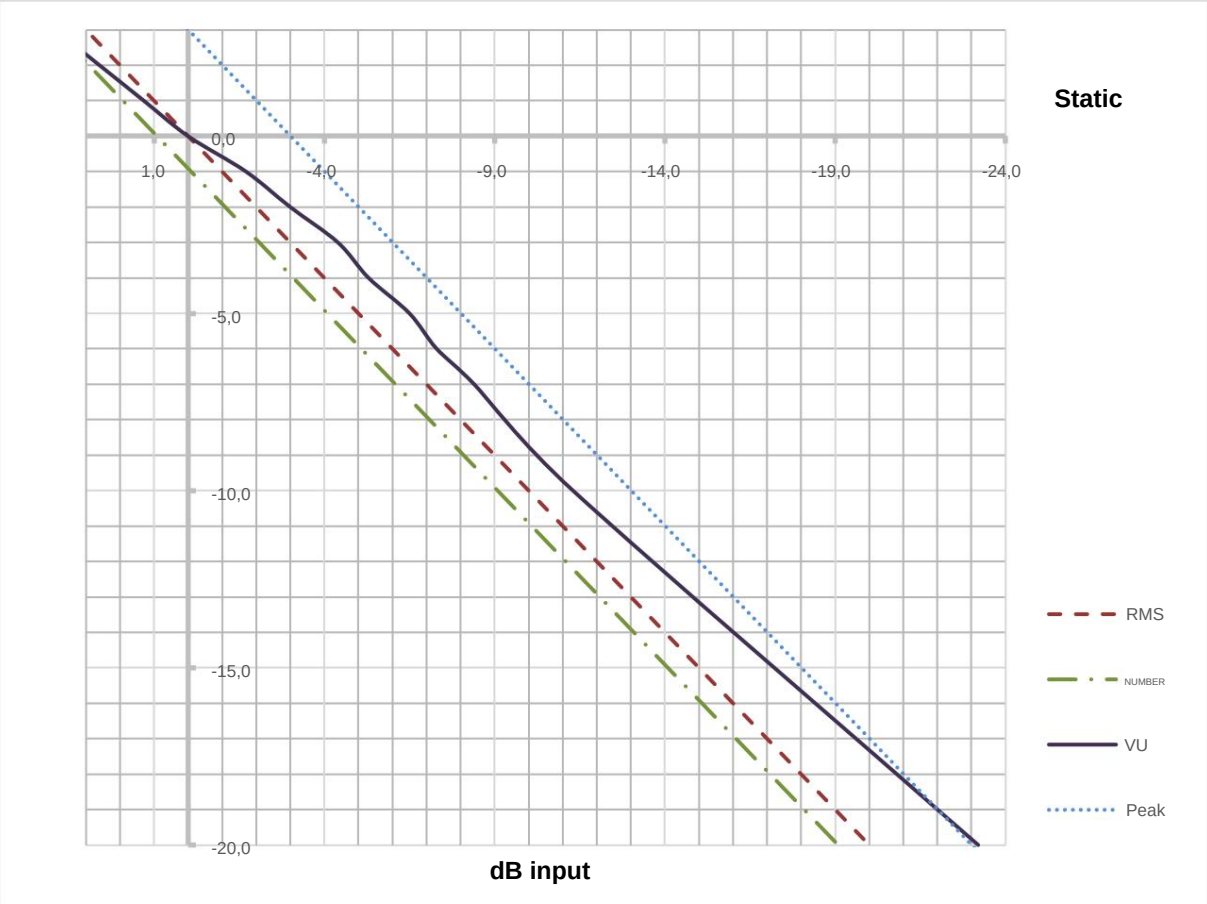

Figure 4.8: Representation of the results of the measurement of the API 2500 Stereo Compressor with a continuous signal with a frequency of 1000Hz

The results of the measurement of the dynamic behavior also vary with this VU meter.
close to the RMS values (see Figure 4.9). The results are consistent across all measured signal frequencies.
The sequences are almost identical.

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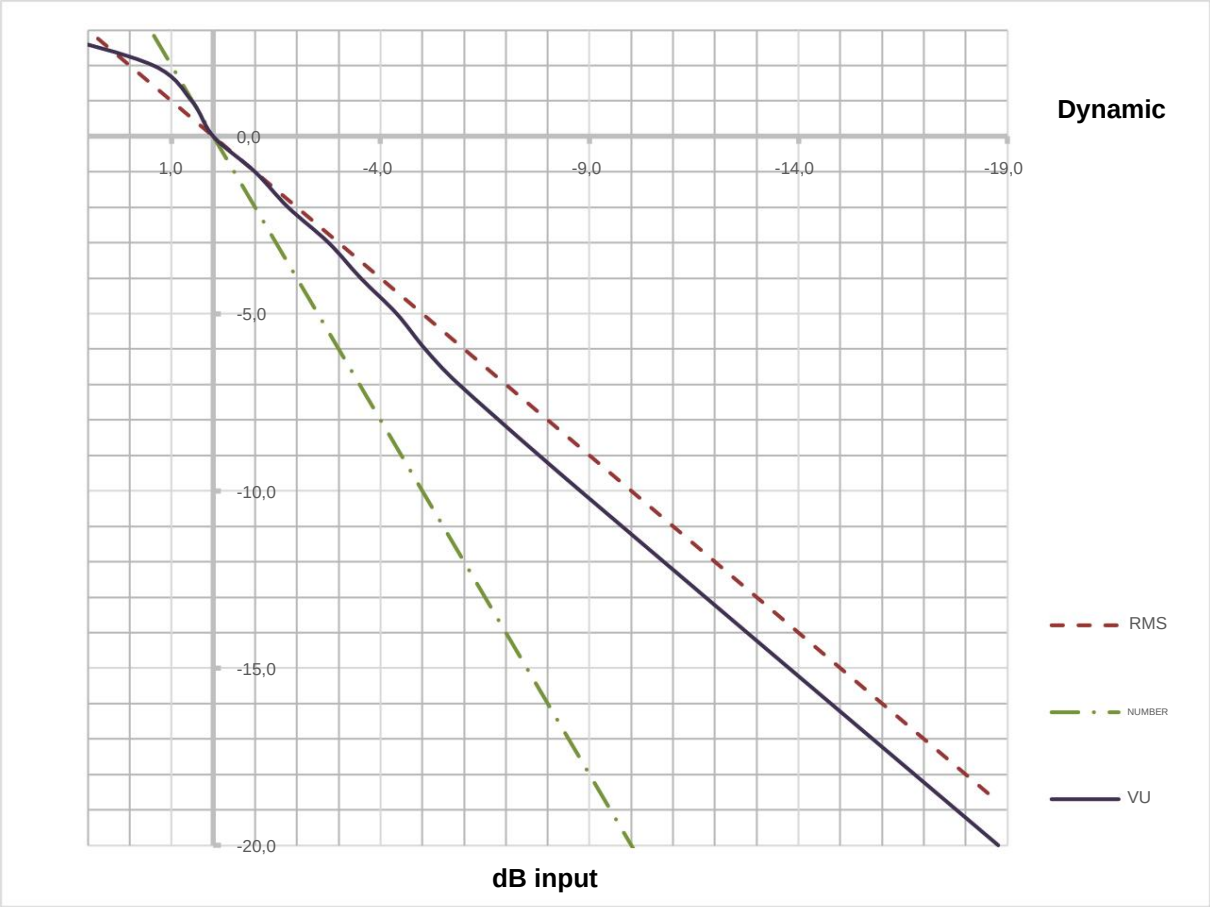

Figure 4.9: Representation of the results of the measurement of the dynamic behavior of the API 2500 Stereo compressors with a signal at a frequency of 1000 Hz

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4.5 Solid State Logic C200HD

Unlike all other VU meters used in the measurement, this device exhibits, in the case of con-
The continuous measurement signal exhibits a very linear display behavior across all frequencies. The measurement
The dynamic behavior provides indications that, at higher applied levels close to the RMS,
lower applied levels lie between RMS and ARV values (see Figure 4.10).
The results are similar for other signal frequencies, with slight variations (see figure).
4.11). A slightly more divergent result may occur with the highest frequency of the signals used.
e.g., with the changed behavior of the device's internal circuitry for signals above a certain threshold.
to justify a certain frequency.

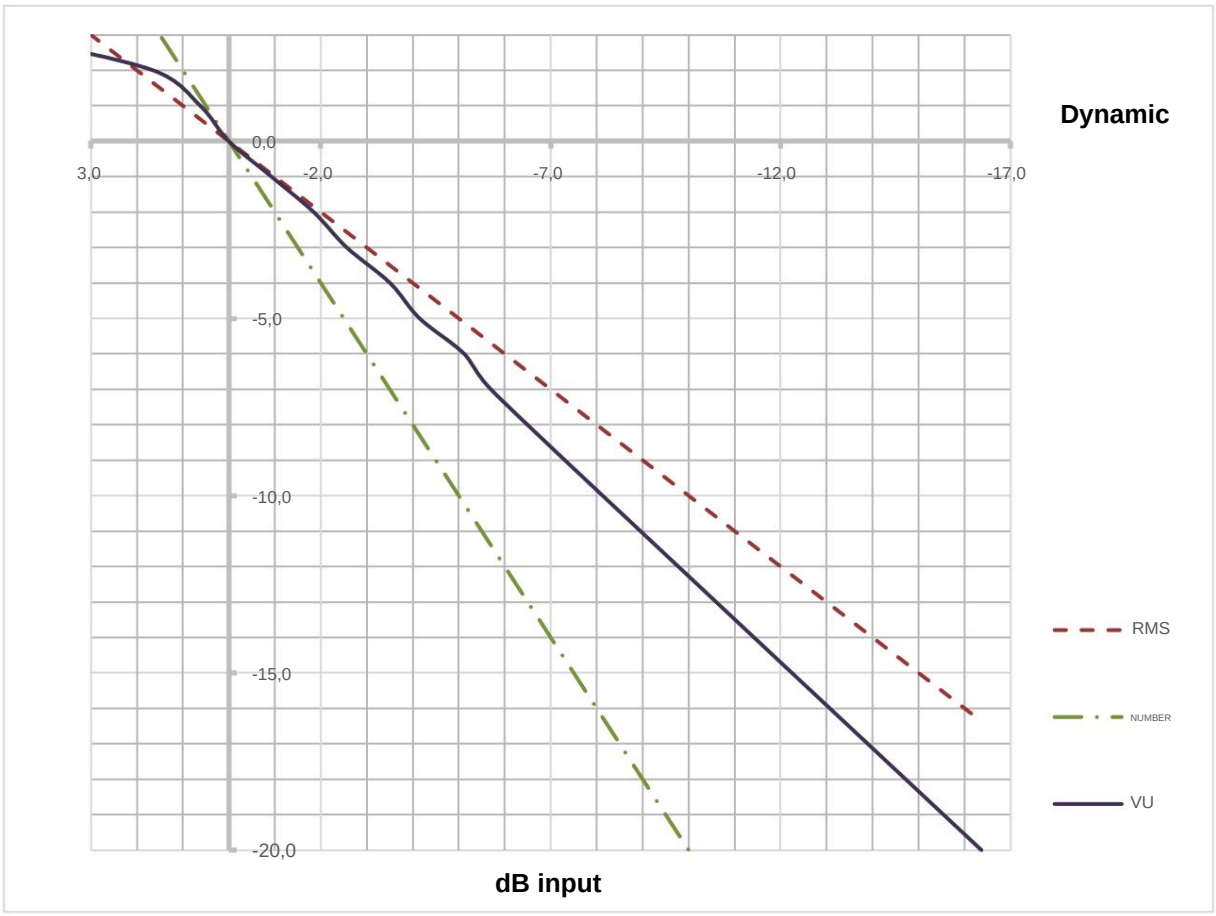

Figure 4.10: Representation of the results of the measurement of the dynamic behavior of the solid state Logic C200HD with a signal at a frequency of 1000 Hz

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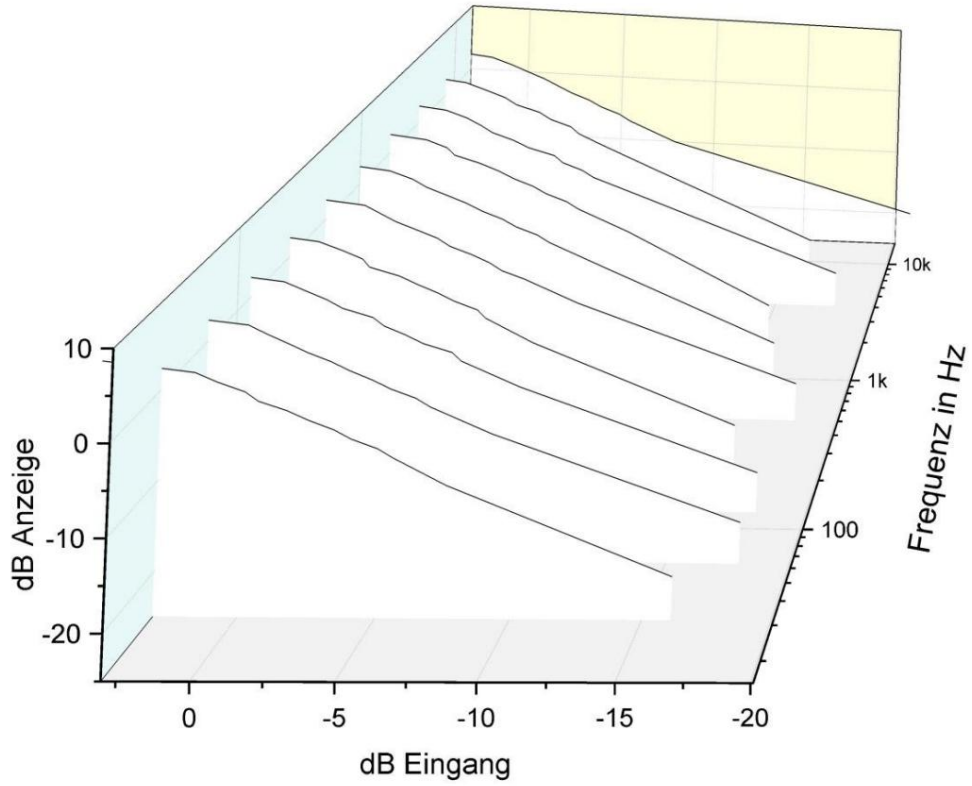

Figure 4.11: Representation of the results of the measurement of the dynamic behavior of the solid state Logic C200HD with signals of different frequencies

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5. Conclusion

The aim of this work was to apply the measurement method developed by Acuña to a specific, user-
to test a selection of control measuring devices, evaluate the results and their further development
to subject the meaning and the measurement method itself to critical scrutiny.

For peak voltage level meters, this type of measurement proves to be only conditionally suitable, since the pulse durations
of the test signals are insufficient for a significant change in the displayed levels.
extremely short choices must be made, and therefore the results provide little insight into the actual events.
allow for dynamic behavior. However, these devices are limited in their ability to exhibit this behavior.
The specification of very short integration times also provides sufficient information for practical use.
Specified, provided that the peak values of signals above this duration are correctly specified.

In contrast, the method used offers a [benefit] with regard to the VU meters employed.
An interesting method of quality control. Many of these devices also seem to function well under very dynamic conditions.
to reproduce the RMS value of the signals approximately as accurately as possible, and thus to closely approximate the human signal.
to influence auditory perception (cf. Friesecke 2014: 414). From a certain impulse duration, the
Signal frequency in the spectrum relevant for sound production has little influence on this process.
to have a consistent reading. In combination with a display of the peak value, these devices could, if well-designed, be useful.
processed, and therefore still primarily in the consumer sector as an alternative to RMS meters
can be used.

Regarding the execution of the measurement, it can be said that the measurement accuracy is improved by using
Measurement setups, as well as the one specified, for example, in DIN IEC 60268-17 for measuring the input-
The oscillation period of VU meters is described (German Institute for Standardization eV 1992: 5), nor
could be significantly increased. Additionally, inaccuracies in the representation of the
to limit dynamic behavior by only including the measured data from the second highest value onwards.
The value of the scale should be included in the representation, as the accurate recognition of a first
A visible reduction of the displayed levels is hardly possible.

While displaying the measured values as relative levels allows for comparison between the measured devices, it doesn't
immediately reveal the pulse duration or signal dynamics at which the displayed levels actually change. However, using
these values would be problematic, as the measurement signal periods vary depending on the device type.

to be chosen, thus establishing a different reference for the crest factor.
This would therefore be of little use as a measure of signal dynamics when characterizing the devices.
Inferential. Further development of the measurement method and its evaluation could therefore, for example,

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The representation of the dynamic behavior in relation to a uniform measure of signal dynamics namik, as well as the use of a uniform period for the test signals.

In summary, the measurement method used is suitable, at least for analog outputs. Control meters with unclear mechanical or circuit-related properties provide a basis for assessing suitability with regard to handling signals of different dynamics mik offers. After further development of the measurement method and presentation, the results could This measurement could certainly be a useful addition to the data sheets of such devices.

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6. Appendix

A1. Measurement data of the RTW 1204A

RMS value of the input voltage at 0 dB **Advertisement**	0.848V
Period of the measurement signal	5000 ms

Signal frequency		31,5 Hz
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,003900
3	3	0,003700
2	2	0,003560
1	1	0,003300
0	0	0,001100
-1	-1	0,000900
-2	-2	0,000800
-3	-3	0,000700
-4	-4	0,000640
-5	-5	0,000600
-6	-6	0,000540
-7	-7	0,000500
-8	-8	0,000460
-9	-9	0,000420
-10	-10	0,000400
-15	-15	0,000280
-20	-20	0,000200
-25	-25	0,000140
-30	-30	0,000100
-40	-40	0,000060

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Signal frequency	63 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,002100
3	3	0,002000
2	2	0,001800
		0,000700
1	1	0,000600
0	0	0,000580
-1 -2	-1 -2	0,000520
-3	-3	0,000440
-4	-4	0,000400
-5	-5	0,000360
-6	-6	0,000340
-7	-7	0,000310
-8	-8	0,000290
-9	-9	0,000270
-10	-10	0,000250
-15	-15	0,000180
-20	-20	0,000140
-25	-25	0,000100
-30	-30	0,000070
-40	-40	0,000040

Signal frequency	125 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001200
3	3	0,001100
2	2	0,001000
1	1	0,000440
0	0	0,000380
-1	-1	0,000340
-2	-2	0,000320
-3	-3	0,000300
-4	-4	0,000280
-5	-5	0,000250
-6	-6	0,000230
-7	-7	0,000210
-8	-8	0,000200
-9	-9	0,000190
-10	-10	0,000170
-15	-15	0,000130
-20	-20	0,000090
-25	-25	0,000070
-30	-30	0,000050
-40	-40	0,000030

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Signal frequency	250 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001600
3	3	0,000800
2	2	0,000600
		0,000560
1	1	0,000520
0	0	0,000320
-1 -2	-1 -2	0,000260
-3	-3	0,000210
-4	-4	0,000190
-5	-5	0,000170
-6	-6	0,000160
-7	-7	0,000150
-8	-8	0,000140
-9	-9	0,000130
-10	-10	0,000120
-15	-15	0,000094
-20	-20	0,000060
-25	-25	0,000050
-30	-30	0,000040
-40	-40	0,00002

Signal frequency	500 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001400
3	3	0,001000
2	2	0,000700
1	1	0,000500
0	0	0,000340
-1	-1	0,000300
-2	-2	0,000280
-3	-3	0,000260
-4	-4	0,000200
-5	-5	0,000134
-6	-6	0,000120
-7	-7	0,000108
-8	-8	0,000100
-9	-9	0,000090
-10	-10	0,000084
-15	-15	0,000062
-20	-20	0,000044
-25	-25	0,000036
-30	-30	0,000024
-40	-40	0,000014

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Signal frequency	1000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001200
3	3	0,000800
2	2	0,000600
		0,000500
1	1	0,000360
0	0	0,000320
-1 -2	-1 -2	0,000260
-3	-3	0,000240
-4	-4	0,000180
-5	-5	0,000160
-6	-6	0,000140
-7	-7	0,000130
-8	-8	0,000126
-9	-9	0,000076
-10	-10	0,000065
-15	-15	0,000044
-20	-20	0,000030
-25	-25	0,000024
-30	-30	0,000016
-40	-40	0,000010

Signal frequency	2000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001600
3	3	0,001000
2	2	0,000640
1	1	0,000500
0	0	0,000400
-1	-1	0,000300
-2	-2	0,000260
-3	-3	0,000220
-4	-4	0,000180
-5	-5	0,000160
-6	-6	0,000135
-7	-7	0,000120
-8	-8	0,000100
-9	-9	0,000090
-10	-10	0,000080
-15	-15	0,000040
-20	-20	0,000025
-25	-25	0,000016
-30	-30	0,000015
-40	-40	0,000006

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Signal frequency	4000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001600
3	3	0,001200
2	2	0,000700
		0,000500
1	1	0,000400
0	0	0,000300
-1 -2	-1 -2	0,000260
-3	-3	0,000230
-4	-4	0,000180
-5	-5	0,000160
-6	-6	0,000140
-7	-7	0,000110
-8	-8	0,000100
-9	-9	0,000090
-10	-10	0,000080
-15	-15	0,000040
-20	-20	0,000020
-25	-25	0,000016
-30	-30	0,000010
-40	-40	0,000008

Signal frequency	8000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001400
3	3	0,001000
2	2	0,000700
1	1	0,000500
0	0	0,000380
-1	-1	0,000340
-2	-2	0,000280
-3	-3	0,000220
-4	-4	0,000190
-5	-5	0,000160
-6	-6	0,000140
-7	-7	0,000120
-8	-8	0,000100
-9	-9	0,000090
-10	-10	0,000080
-15	-15	0,000040
-20	-20	0,000025
-25	-25	0,000018
-30	-30	0,000008
-40	-40	0,000007

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Signal frequency	16000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
4	4	0,001400
3	3	0,000900
2	2	0,000600
		0,000500
1	1	0,000400
0	0	0,000300
-1 -2	-1 -2	0,000260
-3	-3	0,000210
-4	-4	0,000180
-5	-5	0,000160
-6	-6	0,000140
-7	-7	0,000120
-8	-8	0,000100
-9	-9	0,000090
-10	-10	0,000080
-15	-15	0,000040
-20	-20	0,000030
-25	-25	0,000015
-30	-30	0,000007
-40	-40	0,000006

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A2. Measurement data of the self-assembled VU meter

RMS value of the input voltage at 0 dB **Advertisement**	0.715V
Period of the measurement signal	800 ms

Signal frequency		31,5 Hz
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	4,0	0,5000
2	2,8	0,3563
1	1,6	0,2775
0	0,4	0,1988
-1	-1,0	0,1588
-2	-2,3	0,1388
-3	-3,6	0,1063
-4	-5,2	0,0875
-5	-6,6	0,0688
-6	-8,4	0,0563
-7	-9,4	0,0463
-10	-14,0	0,0250
-20	-22,0	0,0113

Signal frequency		63 Hz
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,8	0,5000
2	2,5	0,3375
	1,3	0,2575
1	0,2	0,2188
0 -1	-1,2	0,1688
-2	-2,5	0,1388
-3	-3,8	0,1113
-4	-5,4	0,0888
-5	-6,6	0,0788
-6	-8,3	0,0600
-7	-9,6	0,0500
-10	-13,7	0,0250
-20	-23,8	0,0100

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Signal frequency	125 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	2,4	0,3300
1	1,2	0,2500
0	0,0	0,2000
-1	-1,2	0,1600
-2	-2,6	0,1300
-3	-4,0	0,1100
-4	-5,4	0,0900
-5	-6,9	0,0700
-6	-8,3	0,0550
-7	-9,8	0,0500
-10	20,2	0,0250
-20	-24,5	0,0050

Signal frequency	250 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	2,4	0,3450
1	1,2	0,2600
0	0,0	0,2050
-1	-1,4	0,1600
-2	-2,7	0,1300
-3	-4,0	0,1100
-4	-5,4	0,0850
-5	-6,9	0,0700
-6	-8,5	0,0550
-7	-9,8	0,0450
-10	-14,2	0,0200
-20	-22,0	0,0050

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Signal frequency	500 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	3,7	0,3350
1	1,2	0,2500
0	0,0	0,2000
-1	-1,4	0,1625
-2	-2,7	0,1275
-3	-4,0	0,1050
-4	-5,5	0,0875
-5	-6,9	0,0700
-6	-8,5	0,0563
-7	-9,8	0,0475
-10	-14,2	0,0225
-20	-24,5	0,0050

Signal frequency	1000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	2,3	0,3363
1	1,2	0,2500
0	0,0	0,2000
-1	-1,4	0,1625
-2	-2,8	0,1313
-3	-4,0	0,1088
-4	-5,7	0,0875
-5	-6,9	0,0713
-6	-8,7	0,0575
-7	-9,8	0,0463
-10	-14,2	0,0225
-20	-25,3	0,0038

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Signal frequency	2000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	2,3	0,3313
1	1,2	0,2500
0	0,0	0,2000
-1	-1,4	0,1588
-2	-2,8	0,1313
-3	-4,1	0,1088
-4	-5,5	0,0863
-5	-6,9	0,0713
-6	-8,7	0,0563
-7	-9,8	0,0475
-10	-14,2	0,0213
-20	-23,8	0,0038

Signal frequency	4000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	2,3	0,3375
1	1,4	0,2500
0	0,0	0,2000
-1	-1,4	0,1625
-2	-2,8	0,1313
-3	-4,2	0,1088
-4	-5,7	0,0875
-5	-7,0	0,0725
-6	-8,5	0,0563
-7	-9,8	0,0475
-10	-14,2	0,0225
-20	-24,5	0,0038

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Signal frequency	8000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	2,3	0,3375
1	1,2	0,2500
0	0,0	0,2000
-1	-1,4	0,1625
-2	-2,8	0,1313
-3	-4,0	0,1100
-4	-5,7	0,0875
-5	-6,9	0,0725
-6	-8,5	0,0550
-7	-9,8	0,0475
-10	-14,2	0,0225
-20	-23,0	0,0038

Signal frequency	16000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,6	0,5000
2	2,4	0,3375
1	1,2	0,2500
0	0,0	0,2000
-1	-1,3	0,1625
-2	-2,7	0,1313
-3	-4,0	0,1063
-4	-5,5	0,0838
-5	-6,9	0,0688
-6	-8,7	0,0563
-7	-9,8	0,0438
-10	-14,2	0,0213
-20	-23,8	0,0038

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A3. Measurement data of the DK-Audio MSD100T

RMS value of the input voltage at 0 dB **Advertisement**	0.603V
Period of the measurement signal	800 ms

Signal frequency	31,5 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0813
1	1,0	0,0500
0,5	0,5	0,0475
0	0,0	0,0388
-0,5	-0,5	0,0313
-1	-1,0	0,0300
-2	-2,0	0,0275
-3	-3,0	0,0263
-4	-4,0	0,0250
-5	-5,0	0,0225
-6	-6,0	0,0138
-7	-7,0	0,0113
-10	-10,0	0,0088
-20	-20,0	0,0044

Signal frequency	63 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0788
	1,0	0,0538
1 0,5	0,5	0,0450
0	0,0	0,0400
-0,5	-0,5	0,0350
-1	-1,0	0,0338
-2	-2,0	0,0250
-3	-3,0	0,0225
-4	-4,0	0,0163
-5	-5,0	0,0150
-6	-6,0	0,0138
-7	-7,0	0,0113
-10	-10,0	0,0069
-20	-20,0	0,0031

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Signal frequency	125 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0788
1	1,0	0,0525
0,5	0,5	0,0450
0	0,0	0,0388
-0,5	-0,5	0,0350
-1	-1,0	0,0313
-2	-2,0	0,0263
-3	-3,0	0,0219
-4	-4,0	0,0175
-5	-5,0	0,0163
-6	-6,0	0,0131
-7	-7,0	0,0119
-10	-10,0	0,0075
-20	-20,0	0,0025

Signal frequency	250 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0788
1	1,0	0,0525
0,5	0,5	0,0438
0	0,0	0,0388
-0,5	-0,5	0,0350
-1	-1,0	0,0313
-2	-2,0	0,0263
-3	-3,0	0,0213
-4	-4,0	0,0181
-5	-5,0	0,0150
-6	-6,0	0,0131
-7	-7,0	0,0113
-10	-10,0	0,0075
-20	-20,0	0,0019

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Signal frequency	500 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0763
1	1,0	0,0525
0,5	0,5	0,0438
0	0,0	0,0388
-0,5	-0,5	0,0350
-1	-1,0	0,0313
-2	-2,0	0,0256
-3	-3,0	0,0213
-4	-4,0	0,0175
-5	-5,0	0,0150
-6	-6,0	0,0131
-7	-7,0	0,0113
-10	-10,0	0,0075
-20	-20,0	0,0038

Signal frequency	1000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0800
1	1,0	0,0513
0,5	0,5	0,0450
0	0,0	0,0400
-0,5	-0,5	0,0338
-1	-1,0	0,0300
-2	-2,0	0,0263
-3	-3,0	0,0213
-4	-4,0	0,0175
-5	-5,0	0,0150
-6	-6,0	0,0125
-7	-7,0	0,0113
-10	-10,0	0,0075
-20	-20,0	0,0021

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Signal frequency	2000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0775
1	1,0	0,0500
0,5	0,5	0,0438
0	0,0	0,0388
-0,5	-0,5	0,0338
-1	-1,0	0,0288
-2	-2,0	0,0263
-3	-3,0	0,0213
-4	-4,0	0,0175
-5	-5,0	0,0138
-6	-6,0	0,0125
-7	-7,0	0,0113
-10	-10,0	0,0075
-20	-20,0	0,0023

Signal frequency	4000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0788
1	1,0	0,0500
0,5	0,5	0,0450
0	0,0	0,0400
-0,5	-0,5	0,0338
-1	-1,0	0,0300
-2	-2,0	0,0250
-3	-3,0	0,0200
-4	-4,0	0,0175
-5	-5,0	0,0150
-6	-6,0	0,0125
-7	-7,0	0,0100
-10	-10,0	0,0075
-20	-20,0	0,0022

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Signal frequency	8000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0775
1	1,0	0,0513
0,5	0,5	0,0438
0	0,0	0,0388
-0,5	-0,5	0,0338
-1	-1,0	0,0313
-2	-2,0	0,0250
-3	-3,0	0,0213
-4	-4,0	0,0175
-5	-5,0	0,0138
-6	-6,0	0,0125
-7	-7,0	0,0113
-10	-10,0	0,0075
-20	-20,0	0,0022

Signal frequency	16000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,1750
2	2,0	0,0788
1	1,0	0,0513
0,5	0,5	0,0450
0	0,0	0,0388
-0,5	-0,5	0,0338
-1	-1,0	0,0300
-2	-2,0	0,0250
-3	-3,0	0,0213
-4	-4,0	0,0175
-5	-5,0	0,0150
-6	-6,0	0,0125
-7	-7,0	0,0113
-10	-10,0	0,0075
-20	-20,0	0,0021

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A4. Measurement data of the API 2500 Stereo Compressor

RMS value of the input voltage at 0 dB **Advertisement**	1.218V
Period of the measurement signal	800 ms

Signal frequency		31,5 Hz
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,9	0,5000
2	2,6	0,2625
1	1,3	0,2125
0	0,0	0,1875
-1	-1,7	0,1500
-2	-3,0	0,1250
-3	-4,4	0,1000
-4	-5,4	0,0863
-5	-6,5	0,0688
-6	-7,4	0,0550
-7	-8,4	0,0475
-10	-11,5	0,0250
-20	-23,2	0,0050

Signal frequency		63 Hz
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,9	0,5000
2	2,6	0,2625
	1,3	0,2125
1	0,1	0,1875
0 -1	-1,7	0,1500
-2	-3,0	0,1250
-3	-4,3	0,1000
-4	-5,4	0,0813
-5	-6,5	0,0688
-6	-7,4	0,0550
-7	-8,4	0,0450
-10	-11,5	0,0250
-20	-23,2	0,0025

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Signal frequency	125 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,9	0,5000
2	2,6	0,2625
1	1,3	0,2225
0	0,1	0,1875
-1	-1,6	0,1500
-2	-3,0	0,1250
-3	-4,3	0,1000
-4	-5,4	0,0875
-5	-6,5	0,0688
-6	-7,5	0,0563
-7	-8,5	0,0475
-10	-11,5	0,0250
-20	-23,2	0,0025

Signal frequency	250 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	4,0	0,5000
2	2,7	0,2500
1	1,4	0,2125
0	0,2	0,1875
-1	-1,7	0,1500
-2	-3,0	0,1250
-3	-4,4	0,1000
-4	-5,4	0,0863
-5	-6,5	0,0688
-6	-7,5	0,0550
-7	-8,4	0,0438
-10	-11,6	0,0250
-20	-23,2	0,0025

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Signal frequency	500 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	4,0	0,5000
2	2,7	0,2500
1	1,3	0,2125
0	0,1	0,1875
-1	-1,6	0,1500
-2	-3,0	0,1250
-3	-4,3	0,1000
-4	-5,4	0,0850
-5	-6,5	0,0688
-6	-7,5	0,0550
-7	-8,5	0,0475
-10	-11,6	0,0250
-20	-23,2	0,0025

Signal frequency	1000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,9	0,5000
2	2,6	0,2625
1	1,3	0,2125
0	0,0	0,1888
-1	-1,7	0,1500
-2	-3,0	0,1250
-3	-4,4	0,1000
-4	-5,3	0,0838
-5	-6,5	0,0688
-6	-7,3	0,0588
-7	-8,4	0,0488
-10	-11,3	0,0250
-20	-23,2	0,0025

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Signal frequency	2000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	4,0	0,5000
2	2,7	0,2500
1	1,3	0,2125
0	0,2	0,1875
-1	-1,6	0,1500
-2	-2,9	0,1250
-3	-4,3	0,1000
-4	-5,4	0,0850
-5	-6,5	0,0688
-6	-7,4	0,0550
-7	-8,5	0,0475
-10	-11,6	0,0250
-20	-23,2	0,0025

Signal frequency	4000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	4,0	0,5000
2	2,7	0,2500
1	1,3	0,2125
0	0,1	0,1875
-1	-1,6	0,1500
-2	-3,0	0,1250
-3	-4,3	0,1000
-4	-5,4	0,0863
-5	-6,5	0,0688
-6	-7,4	0,0550
-7	-8,5	0,0475
-10	-11,5	0,0250
-20	-23,2	0,0025

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Signal frequency	8000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,9	0,5000
2	2,7	0,2500
1	1,3	0,2125
0	0,1	0,1875
-1	-1,7	0,1500
-2	-2,9	0,1250
-3	-4,5	0,1000
-4	-5,3	0,0850
-5	-6,5	0,0688
-6	-7,3	0,0588
-7	-8,5	0,0475
-10	-11,5	0,0250
-20	-23,2	0,0025

Signal frequency	16000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,8	0,5000
2	2,6	0,2500
1	1,2	0,2125
0	-0,1	0,1875
-1	-1,7	0,1500
-2	-3,0	0,1250
-3	-4,5	0,1000
-4	-5,6	0,0850
-5	-6,6	0,0700
-6	-7,5	0,0588
-7	-8,7	0,0475
-10	-11,7	0,0250
-20	-23,2	0,0025

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A5. Measurement data of the Solid State Logic C200HD

RMS value of the input voltage at 0 dB Advertisement	1.188V
Period of the measurement signal	800 ms

Signal frequency		31,5 Hz
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3,0	0,5000
2	2,0	0,2338
1	1,0	0,1938
0	0,0	0,1538
-1	-1,1	0,1375
-2	-2,0	0,1075
-3	-3,0	0,0900
-4	-4,0	0,0725
-5	-5,0	0,0625
-6	-6,0	0,0500
-7	-7,0	0,0438
-10	-10,9	0,0275
-20	-19,9	0,0038

Signal frequency		63 Hz
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	1,9	0,2213
		0,1875
1	1	0,1563
0 -1	0 -1	0,1313
-2	-2	0,1063
-3	-3	0,0900
-4	-4	0,0738
-5	-5	0,0625
-6	-6	0,0500
-7	-7	0,0438
-10	-10,1	0,0250
-20	-20	0,0025

Machine Translated by Google

Signal frequency	125 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	2	0,2275
1	1	0,1875
0	0	0,1538
-1	-1	0,1325
-2	-2	0,1000
-3	-3	0,0900
-4	-4	0,0738
-5	-5	0,0625
-6	-6	0,0475
-7	-7	0,0438
-10	-9,9	0,0250
-20	-19,9	0,0025

Signal frequency	250 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	2	0,2350
1	1,1	0,1875
0	0	0,1538
-1	-1	0,1438
-2	-2	0,1075
-3	-3	0,0900
-4	-4	0,0738
-5	-5,2	0,0625
-6	-6	0,0500
-7	-7	0,0463
-10	-10	0,0288
-20	-20	0,0038

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Signal frequency	500 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	2	0,2225
1	1	0,1900
0	0	0,1625
-1	-1	0,1313
-2	-2	0,1063
-3	-3	0,0938
-4	-4	0,0750
-5	-5	0,0625
-6	-6	0,0550
-7	-7	0,0438
-10	-10	0,0250
-20	-20	0,0025

Signal frequency	1000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	2	0,2375
1	1	0,1875
0	0	0,1625
-1	-0,9	0,1313
-2	-2	0,1063
-3	-3	0,0900
-4	-4	0,0725
-5	-5	0,0625
-6	-6	0,0500
-7	-7	0,0438
-10	-10	0,0250
-20	-19,9	0,0038

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Signal frequency	2000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	2,9	0,5000
2	2	0,2350
1	1	0,1875
0	0	0,1725
-1	-1	0,1313
-2	-2	0,1063
-3	-3	0,0900
-4	-4	0,0725
-5	-5	0,0625
-6	-6	0,0500
-7	-7	0,0438
-10	-10	0,0250
-20	-20	0,0050

Signal frequency	4000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	2	0,2375
1	1	0,1875
0	0	0,1600
-1	-1	0,1400
-2	-2	0,1100
-3	-3	0,0925
-4	-4	0,0688
-5	-5	0,0625
-6	-6	0,0500
-7	-7	0,0438
-10	-10	0,0225
-20	-20	0,0025

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Signal frequency	8000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	1,9	0,2375
1	1	0,1875
0	-0,1	0,1500
-1	-1	0,1313
-2	-2	0,1000
-3	-3	0,0875
-4	-5,2	0,0688
-5	-5	0,0625
-6	-6	0,0525
-7	-7	0,0438
-10	-10	0,0250
-20	-20	0,0038

Signal frequency	16000 Hz	
Display in dB	**Set level in dBFS (continuous signal)**	**Key rate (gepulstes Signal)**
3	3	0,5000
2	2	0,2375
1	1	0,1875
0	0	0,1538
-1	-1	0,1250
-2	-2	0,1063
-3	-3	0,0900
-4	-4	0,0725
-5	-5	0,0625
-6	-6	0,0500
-7	-7	0,0438
-10	-9,8	0,0250
-20	-20	0,0013

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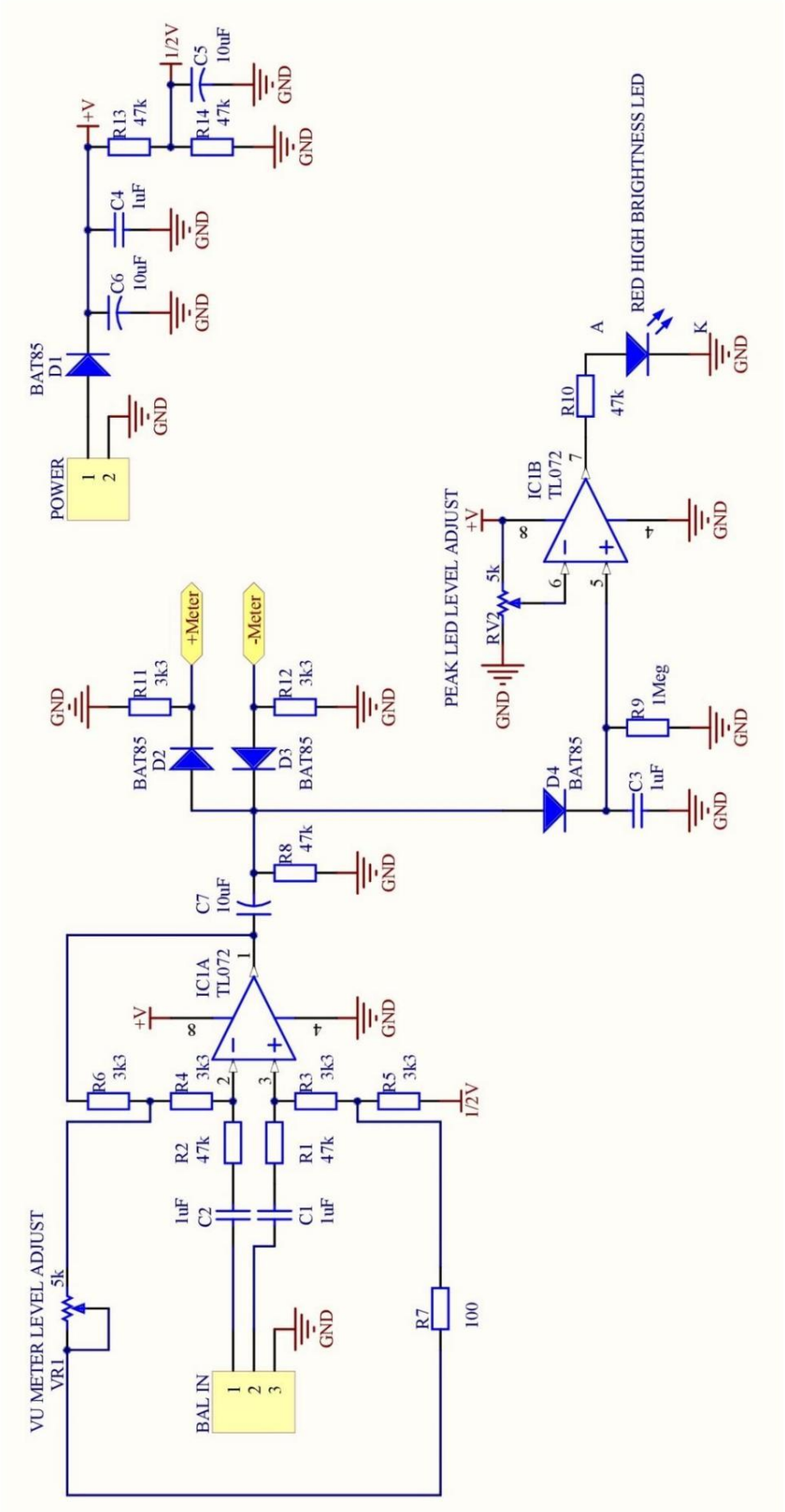
A6. Circuit diagram of the JLM Audio VU-meter buffer



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Declaration of independence

I hereby certify that I have completed the present bachelor's thesis entitled: **"Measurement Technology**

Investigation of the response of level meters to signals of different dynamics"

Written independently without outside help and using no sources or aids other than those indicated.

to have used. The passages taken verbatim from other works or adapted in meaning-

Rejected passages are clearly identified through source citations.